PETROLOGICAL NOTES. No. i. IGNEOUS ROCKS AND TUFF FROM THE CARBONIFEROUS OF NEW SOUTH WALES.

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(Plate xl.)

Introduction.—The study of the genetic and tectonic relationships of the Carboniferous igneous rocks of New South Wales is a work of pressing importance in Australian petrology, and one which I had planned to take up, but my removal to Western Australia has caused its abandonment, at any rate for some years.

The following notes represent a small amount of preliminary collecting and study. The field-relations of the rocks dealt with have not yet been worked out, but are indicated to some extent on Professor David's maps (David, 1907).

The igneous rocks are interbedded with littoral sedimentaries and tuffs belonging to the upper part of the Lower Carboniferous (Benson, 1913, Pt. i.), but, owing to the absence of persistent horizons in the sedimentaries (Jaquet, 1901), correlation will depend largely on the igneous rocks. For this reason, and as the rocks described will have to be identified in the field as mapping proceeds, the descriptions have been made fairly detailed.

The rocks to be described are from Martin's Creek, near Paterson; and Eelah, Hudson's Peak and Knockfin, near Gosforth, in the Hunter River Valley, N.S.W.

Martin's Creek, Paterson.

(108) *Pyroxene-amphibole-mica andesite.* – A handsome greenish to brownish-grey rock with occasional red patches; porphy-

ritic with numerous white felspars and subordinate hornblendes up to 3 mm. long; the felspars frequently appear to invest a ferromagnesian kernel; the fracture is smooth and subconchoidal.

Microscopically, the primary minerals developed are plagioclase, hornblende, biotite, rhombic pyroxene, magnetite, apatite, and zircon.

The plagioclase is an oligoclase-andesine, with a maximum symmetrical extinction of 16°. It is of subequant habit, twinned on the Carlsbad, albite, and pericline laws, and is appreciably zoned, though the variations in composition are but slight; the kernels are acidic, and sharply separated from the more basic outer zones. The felspar has a peculiar spangled appearance, due to the formation of resorbtion-cavities, and the development of cleavage- and fracture-cracks and sericite-scales. The acidic kernels are often completely replaced by pseudomorphs of a blue-green chlorite, rather strongly pleochroic and weakly birefringent, with a fibrous, spherulitic habit. The boundaries of these aggregates are quite sharp, and concentric with the zoning of the felspar. Zircon is the only mineral included.

Common hornblende is greatly subordinate in amount to plagioclase. Its pleochroism and absorbtion are, $\mathfrak{a}$ pale greenish-yellow, $\mathfrak{b}$ yellow-green, $\mathfrak{c}$ green, with $\mathfrak{a} < \mathfrak{b} < \mathfrak{c}$. It includes zircon, magnetite, and apatite, and patches of exceedingly minute rods lying parallel to C in the (110) cleavage-planes. It is surrounded by reaction-rings of moderate depth, the pyroxene of which has altered to a grass-green, strongly pleochroic chlorite with a birefringence equal to that of quartz, while the magnetite-granules are passing into limonite.

Biotite occurs in thin, bent flakes, much altered, and so strongly resorbed as to be represented, at times, by a mere string of magnetite-granules.

Rhombic pyroxene is very scarce, and almost completely altered. It is a pale, feebly pleochroic hypersthene, passing into pseudomorphic aggregates of blue-green chlorite, and brown, pleochroic anthophyllite. Alteration proceeded with the paramorphic formation of anthophyllite inwards from the sides and transverse fractures, while chlorite formed internally.

Zircon is comparatively abundant, as is magnetite, which includes apatite, and is passing peripherally into limonite. Apatite is scarce, but is peculiar in showing prismatic cleavage.

The groundmass is pale brownish in colour, with a slightly fluidal fabric in places, and is thickly dusted with magnetite, limonite, and chlorite. In ordinary light, it has the appearance of a typical glass. It consists, however, of a very fine-grained mosaic of untwinned plagioclase, more acid than the phenocrysts. The separate grains are independent of flow-lines or inclusions in their orientation. The mosaic, hence, represents a devitrified plagioclase-glass. Small nests of granular quartz, perhaps secondary, occur occasionally. (Pl. xl., fig.3).

This rock has been extensively quarried for use as ballast on the North Coast Railway.

EELAH.

(113) *Hypersthene-andesite.*—A very dark brown, heavy rock, with a rough, uneven fracture, and granular appearance; porphyritic with numerous, yellow, glassy felspars up to 3 mm. long, which weather to a brown colour. The rock, as a whole, develops an earthy crust on weathered surfaces, on which the felspars stand out in slight relief.

Plagioclase, hypersthene, magnetite, apatite, and zircon are developed. (Pl. xl., fig.4).

The plagioclase is a basic labradorite, with a maximum symmetrical extinction of 35°, twinned on the Carlsbad, albite, and pericline laws; habit idiomorphic, subequant, with slightly rounded outlines, distinctly corroded by the groundmass in places. Zoning is well marked, but the variations in composition are only slight, and are not progressive. Generally, there is an even basic core, followed by several oscillations, with a well marked acidic outer shell. Stony inclusions tend to concentrate in the zones of oscillating composition. The felspar is generally fresh and unaltered, though fractured. Limonite has been deposited in the cracks. Small grains of hypersthene are included.

Hypersthene forms stout columnar crystals of rounded outline, and is not very abundant. The colour is fairly deep; pleochroism and absorbtion are as follows :—$\mathfrak{a}$ brownish-pink, $\mathfrak{b}$ brownish-yellow, $\mathfrak{c}$ greenish-grey; $\mathfrak{a}>\mathfrak{b}\leqq\mathfrak{c}$. Multiple twinning is common. Magnetite is often, but felspar seldom, included. Aggregates of irregularly intergrown hypersthene and felspar occur, and large felspars are sometimes moulded on to large hypersthenes. Evidently, the crystallisation of hypersthene commenced slightly before felspar; the periods overlapped, but hypersthene finished first. Alteration to bastite is taking place.

Magnetite is fairly abundant in rounded grains passing into limonite. Apatite and zircon are very rare.

The groundmass consists of minute felspar and hypersthene individuals set in a preponderant glass. It is partly replaced by limonite and bastite.

(103) *Pyroxene-andesite.*—A compact, dark green, serpentinous rock, porphyritic with numerous indistinct, greenish felspars up to 4 mm. long, which become white on exposure, and finally weather out; exposed surfaces, thus, have a rough, pitted appearance, and are dark brown in colour; fracture fairly smooth.

Phenocrysts and groundmass are in about equal proportions. The minerals developed are plagioclase, pyroxene, magnetite, and apatite.

The plagioclase is a basic labradorite, with a maximum symmetrical extinction of 31°, tabular-prismatic in habit, with wide albite lamellæ, and an occasional pericline-set. Zoning is present, with slight oscillatory changes in composition as in (113). The general change is from a basic centre to a more acid margin, but there are often one or two zones more acid than the outer shell. The felspar is sometimes moulded on to pyroxene-pseudomorphs, and includes magnetite. Minute stony inclusions are zonally distributed. The crystals are much fractured and, at times, recemented. The fractures are filled with yellow-green clinochlore, which also occurs sporadically in the crystals, but shows a marked preference for pseudomorphic replacement of the acid zones. The centres of small crystals are entirely replaced, whereas in larger ones there are one or two ragged zones of chlorite, concentric with those of the felspar. Irregular carbonate-replacements also occur.

Pyroxene is represented by idiomorphic pseudomorphs of clinochlore and carbonate, in which traces of original cleavage and fracture are preserved. Magnetite and apatite are included. The original pyroxene appears to have been rhombic, and was considerably less in amount than felspar. Alteration proceeded inwards from the sides of the fractures, and outwards from scattered centres in the crystals.

Magnetite is moderately abundant, and is passing into limonite. Apatite is quite rare.

The chlorite of the rock (clinochlore) is in ragged plates and fibrous spherulitic aggregates, yellow-green in colour, weakly pleochroic, with a birefringence equal to that of quartz.

The groundmass is of normal appearance in ordinary light, thickly dusted with magnetite, limonite, and chlorite, and here and there replaced by chlorite; a few tiny patches are clear, and free from inclusions. It is holocrystalline, being a mosaic of interlocking, untwinned plagioclase-grains, more acid than the phenocrysts. As in (108), it is a devitrified plagioclase-glass, but here the grainsize is much coarser, averaging 0·3 mm. (Pl.xl., figs.1-2). The clear patches, in ordinary light, are nests of quartz.

The order of crystallisation was normal.

(105) *Pyroxene-amphibole-mica andesite.*—A dirty puce-coloured rock, porphyritic with numerous white felspars up to 3 mm. long, and subordinate hornblendes of similar size. The felspars often invest a ferromagnesian kernel. The groundmass is replaced in patches by chlorite. The rock is soft, and evidently much weathered, and tends to split in definite directions; fracture smooth.

Plagioclase, hornblende, biotite, pyroxene, magnetite, zircon, apatite, and quartz are developed (cf.108).

The plagioclase is an oligoclase-andesine, with a maximum symmetrical extinction of 15°. It resembles that of (108) exactly, in both primary and secondary characters, even to the replacement of the kernels by chlorite (here clinochlore) [Pl. xl., fig.5].

Common hornblende, subordinate in amount to felspar, is like that of (108) in pleochroism and absorbtion. The reaction-rings are slightly deeper, however, and all trace of their secondary pyroxene has been removed, while the granular magnetite is greatly decomposed. Apatite and primary magnetite are included; in one case, hornblende appears to have grown in parallel position with pyroxene (represented by a pseudomorph).

Biotite is in about the same amount as hornblende, and has suffered greatly by resorbtion.

Pyroxene is represented entirely by pseudomorphs. These are generally of clinochlore, carbonate, and quartz, but in three cases, grains of acid plagioclase, with undulose extinction, enter into their composition. Magnetite and apatite are included.

Magnetite includes apatite, and is passing into limonite. Zircon is comparatively abundant, but apatite is scarce.

One minute, rounded grain of quartz was observed. It is undoubtedly primary, being corroded by the groundmass.

The groundmass is greatly clouded by limonite and chlorite, and is, in patches, entirely replaced by chlorite. Fluidal fabric is feebly developed. As in (108), it is a holocrystalline, fine-grained mosaic of plagioclase more acid than the phenocrysts.

In all its primary, and most of its secondary characters, this rock is the exact counterpart of (108). The differences are of degree, rather than of kind.

In a more weathered specimen of the same rock, hornblende is represented by pseudomorphs of allotriomorphic plagioclase which approaches albite in composition, all indices of refraction being lower than Canada balsam. The extinction of the grains is sometimes undulose, and they enclose strings and patches of very finely granular epidote, as well as the apatite-inclusions of the original hornblende. The entire aggregates are surrounded by the reaction-rings of magnetite, which express the characteristic outlines of the hornblende.

In the same specimen, the larger biotites enclose numerous grains of secondary albite, in poikilitic fashion.

A slide of this rock was treated with hydrochloric acid in order to remove limonite; the chlorite-pseudomorphs of pyroxene were noticed to have lost colour, contracted, and become almost isotropic, after the treatment.

Fluidal fabric is better developed in the groundmass of (105) than in that of (108), and the scale of devitrification is somewhat finer in the former than in the latter.

(112) *Biotite-dacite.*—A puce-coloured rock not unlike (105) in appearance, but of rough fracture, and possessing free quartz. Phenocrysts of quartz up to 3 mm., felspar up to 2·5 mm., and biotite are discernible. Felspar preponderates slightly over quartz, while biotite is quite subordinate in amount. The rock resembles the dacite of Rigel, Kohlbach, Hungary, in appearance (Krantz Coll.).

Quartz, orthoclase, plagioclase, biotite, hornblende, magnetite, ilmenite, zircon, and apatite occur.

The quartz is in subidiomorphic to rounded grains, with abundant inclusions and inlets of the groundmass. It contains many, fine, stony inclusions, and large inclusions of glass, each containing a gas-bubble. Strain about the inclusion has been relieved by cracking of the quartz, as in the rhyolite of Eureka, Nev.(Iddings, 1911, p.70, fig.37), and the quartz-porphyry of Dossenheim(Rosenbusch-Iddings, 1905, pp.14-18, Pl. vi.).

Orthoclase is more abundant than plagioclase, and forms idiomorphic, tabular-prismatic crystals, with inclusions of sericite, epidote, and carbonate.

The plagioclase is a calcic oligoclase, with a maximum symmetrical extinction of 7°. It is slightly zoned, the basic kernels being fairly well marked-off from the acid outer shells. Carlsbad-albite twins occur, and the crystals are equant, with rounded corners. They are often spangled by resorbtion-cavities, cracks, and sericite-scales, and are partly replaced by carbonate. Magnetite is included.

The biotite is in strongly absorbtive, bent flakes, surrounded by narrow reaction-rims of granular magnetite. It includes zircon, iron-ores, and apatite.

One piece of chloritised hornblende was observed, surrounded by a narrow reaction-rim.

Judging from their decomposition-products, magnetite and ilmenite coexist; magnetite is in excess, and both include zircon and apatite.

Zircon is plentiful in small, stout grains, while apatite is rare. The groundmass is fluidal in places, elsewhere imperfectly spherulitic. It is greatly clouded by secondary products (limonite, leucoxene, epidote, and chlorite), and is completely devitrified to a fine mosaic of felspar and quartz.

(104) *Oligoclase-biotite rhyolite.*—A light, tough rock, creamy to pink in colour, weathering to a yellow-brown. Scattered, hexagonal flakes of biotite occur. The fracture is very irregular and rough.

Plagioclase, quartz, biotite, and magnetite occur as phenocrysts, all very sparingly.

The groundmass is fluidal, and is completely devitrified, consisting of a microcrystalline mosaic of quartz and felspar, with imperfect felspar-spherulites. It includes numerous margarites. The felspar has a refractive index sometimes greater, sometimes less than that of quartz, and the arms of the extinction-crosses of the spherulites are parallel to the cross-wires. It is, hence, an oligoclase. The phenocrysts of plagioclase are more basic, but do not exhibit twinning. The scanty quartz-phenocrysts are strongly corroded. The biotite is in bent flakes, and is strongly absorbtive. The pleochroism and absorbtion are, $\mathfrak{a}$ pale yellow, $\mathfrak{b}$ black, $\mathfrak{c}$ black; $\mathfrak{a} < \mathfrak{b} = \mathfrak{c}$. The magnetite is passing into limonite.

(114) *Tuffaceous, porphyritic rhyolite.*—A compact, yellow-brown rock, porphyritic with fairly numerous quartzes and white felspars up to 3·5 mm. in diameter. The fracture is rough, and weathered surfaces are a dirty-grey. The rock has the appearance of a typical quartz-porphyry.

Quartz, orthoclase, plagioclase, biotite, hornblende, iron-ore, and zircon are developed.

The quartz is, in all respects, like that in (112).

Orthoclase is next in abundance, forming stout, tabular-prismatic grains, slightly resorbed.

The plagioclase is in small, equant crystals, and is not abundant. It is a slightly calcic oligoclase, with a maximum symmetrical extinction of 4°. Carlsbad, albite, and pericline twins occur. It has the spangled appearance before-mentioned, and includes zircon. Some crystals are broken and recemented, others are rounded.

Biotite is scanty and much altered. It resembles that of (104). The plates are sometimes bent.

Hornblende is represented by rare chlorite-pseudomorphs.

The magnetite, surrounded by yellowish earthy haloes, is apparently titaniferous. Zircon is common, and is included in magnetite.

The subfluidal groundmass is rendered yellow by limonite, chlorite, and epidote particles. Suitable illumination reveals innumerable little cuspate bodies, exactly like the collapsed bubbles of many tuffs. The rock is not a tuff, as the groundmass distinctly corroded the quartz and felspar; but these bodies undoubtedly represent an intermixture of tuffaceous material. They have been filled with quartz, and their felspathic walls have devitrified along with the groundmass, which is a microcrystalline mosaic of quartz and felspar; they are, hence, not apparent between crossed nicols.

(117) *Porphyroid tuff* (Pl. xl., fig.6).—A very tough, compact rock of dark red colour, consisting of scattered grains of quartz and felspar up to 2·5 mm. in diameter, in an even, aphanitic matrix containing occasional, soft, brown patches, which effervesce strongly with acids; even the harder, red part effervesces to a degree. The fracture is smooth but splintery. In hand-specimens, the rock would be taken for a quartz-felspar porphyry. It develops a thin, brown, earthy crust on weathering.

The individualised matter consists of grains and fragments of quartz, orthoclase, calcic oligoclase, bent and ragged flakes of biotite, and grains of magnetite, precisely similar to those in the associated igneous rocks.

The matrix consists of minute, close set, cuspate bodies of exceedingly fantastic forms, representing the collapsed bubbles of a dispersed pumice. They have been subsequently filled with clear quartz, and their walls have devitrified, giving, at first, the false impression that the matrix consists essentially of cuspate quartz-splinters, of extraordinary and impossible forms. The interstices between the bubbles are filled with granular felspar, quartz, and carbonate, in variable proportions, carbonate becoming dominant in some patches. The interstitial material is very thickly clouded with limonite-dust, which gives the rock its red colour. Consolidation has evidently been brought about by the introduction of quartz and carbonate.

Texturally, the rock bears a close resemblance to the porphyroid tuff of Steimel, near Schameder, Westphalia (Lossen, 1883), and to the andesitic tuff from the Old Red of Inverinan, Argyllshire (Kynaston, 1901), but differs from both in several important respects.

Hudson's Peak.

(390) *Porphyritic pitchstone.*—A black aphanite, with a pitch-like lustre, and a very rough, subconchoidal to hackly fracture; extremely brittle.

Plagioclase, hypersthene, biotite, magnetite, zircon, and apatite occur.

The plagioclase is strongly zoned, and appears to change from labradorite within to andesine without. There was one well-marked change, followed by several minor oscillations. There are cavities and inclusions in the outer zones. Carlsbad, albite, and pericline twins occur, as well as complex aggregates. Apatite, zircon, biotite, hypersthene, and magnetite are included.

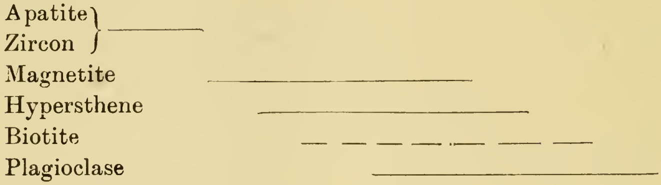
The hypersthene is in rounded grains, of very weak colour and pleochroism, but of negative sign. It includes zircon, apatite, and small felspars, and is partly moulded on, but mostly includes magnetite.

Biotite is strongly pleochroic, includes zircon and apatite, and is moulded on to magnetite.

Magnetite, zircon, and apatite are not remarkable.

The groundmass is very strongly fluidal, consisting of alternating streaks of yellow-brown, and colourless glass differing in their refractive indices, and, seemingly, representing a residuum in the act of splitting into two immiscible fractions. It contains fragments of a foreign, trachytic rock.

The rock is interesting in that it shows the order of crystallisation, which is :—



The position of biotite is uncertain.

The fragmentary evidence afforded by the other rocks agrees with this order.

(162) *Felspathic andesite.*—A fresh-looking, yellowish to reddish-brown rock, porphyritic with numerous, glassy yellow felspars up to 2 mm. long; fracture fairly smooth, but splintery. The specimen studied contains a small fragment of a foreign, black, cherty rock.

Plagioclase, magnetite, zircon, and apatite are developed. Femic minerals are represented by occasional doubtful pseudomorphs.

The plagioclase is an andesine, twinned on the Carlsbad, albite, and pericline laws. It is well zoned, passing from a basic kernel, through several oscillations, to an acid margin. It is slightly spangled by resorbtion-cavities, and the centres of some crystals are partly replaced by chlorite, epidote, and sericite. Some of the crystals are broken and recemented. Magnetite, zircon, apatite, and, in one place, vestigial hornblende(?) are included. Corrosion by the groundmass is very slight.

Scanty pseudomorphic aggregates of quartz, chlorite, and epidote, are the sole representatives of pyroxene or amphibole.

Biotite is completely altered and very rare. One piece is represented by a mosaic of secondary quartz and chlorite, through which run thin parallel strings of minute stony inclusions, indicating the original biotite-cleavages.

Magnetite includes zircon and apatite. Zircon is more abundant than apatite.

The groundmass is greatly clouded with limonite, epidote, and chlorite, but a fluidal fabric is still recognisable. It consists, like that of (108), (103), and (105), of a fine mosaic of untwinned plagioclase, more acid than the phenocrysts, and contains small fragments of a foreign trachytic rock (cf.390).

I am indebted to Professor Woolnough for calling my attention to this rock.

KNOCKFIN.

(391) *Porphyritic rhyolite.*—A very fresh, light pinkish-brown rock, porphyritic with fairly plentiful quartzes and pink felspars up to 2·75 mm. in diameter. The fracture is smooth, but irregular and splintery, and small fragments are milky and translucent on thin edges. In hand-specimens, the rock would be classed as a quartz-porphyry.

Quartz, felspar, biotite, magnetite, and zircon occur.

The quartz is strongly corroded, and has many inclusions and inlets of the groundmass.

Two felspars are developed, but twinning is only feebly expressed, and suitable comparisons of refractive index were not obtained. One is optically negative, and forms simple Carlsbad-twins. It is, doubtless, orthoclase. The other is optically positive, multiply twinned, with low symmetrical extinction-angles, and seems to be albite-oligoclase. It is slightly spangled. Carbonate-replacement occasionally occurs.

Biotite is exceedingly rare.

A few grains of zircon are present, while magnetite is scarce.

The groundmass is fresh-looking, slightly cloudy, and strongly fluidal. It has devitrified to a fine, quartz-felspar mosaic. The felspar preponderates over quartz, has a refractive index lower than that of quartz, and is in fibrous aggregates, sometimes spherulitic, but more often forming long strings with the fibres transverse to the lines of flow. The slight cloudiness of the felspar reveals the fluidal fabric. In some respects, this rock resembles (114).

Review and Conclusions.—Viewed collectively, the igneous rocks above-described present many features of interest.

The question of the mode of origin of these rocks is one on which little can be said. From internal evidence, the writer was disposed to think them all to be volcanic, but Professor David states, "recently I have examined further sections in the neighbourhood of Wallarobba (between Martin's Creek and Dungog), and found, close to the Wallarobba Station, a most interesting section showing Martin's Creek Andesite strongly intrusive, as a sill, into the Carboniferous sedimentary rocks. Since seeing this section, I have now no doubt whatever that, at Martin's Creek also, the rock is strongly intrusive. . . . . . There can be no doubt, I think, that sill-structure is much more extensively developed in the Carboniferous rocks than we had previously any idea of."*

Mr. W. N. Benson also writes to me, concerning the hypocrystalline hypersthene-andesite of Duri Peak, near Currabubula, "I believe it to be part of a great sill of several miles in extent, and several hundred feet in width, but I have not finished field-work thereon."†

In the face of this evidence, it is unsafe to make any assertions based on microscopical information, unsupported by field-relations. Nevertheless, the frequent occurrence of tuffs and tuffaceous sedimentaries, renders the occurrence of lavas also in the highest degree probable.

This uncertainty of origin introduces difficulties of nomenclature. For the sake of uniformity, however, it has been thought of advantage to adhere to the volcanic names hitherto used for these rocks. Greater precision can be attained only with increased knowledge of field-relations.

The rocks are all subalkalic in character.

The proportion of ferromagnesian to salic minerals in the phenocrysts is small, except in (113): and where devitrification has revealed the nature of the groundmass, the proportion in the whole rock is seen to be much smaller. This poverty in femic material has been noticed in the Pokolbin rocks (Browne and

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* Letter to author, February 23rd, 1915.

† Letter dated March 26th, 1915.

Walkom, 1911), and in those of the Bingara-Barraba district (Benson, 1913, Pt. iii.).

The effects of physical instability in the magma (Harker, 1909, Ch. ix.) are widespread in the rocks described, but have not been noted elsewhere in the series, except in the quartzes of Pokolbin. The corrosion of the quartzes and felspars was probably due to the sudden change from plutonic conditions on eruption, but the resorbtion of the hornblendes and biotites, and the zoning of the felspars were undoubtedly intratelluric.

In four rocks, from three localities, *the groundmass has the exact composition of a felspar, being a devitrified felspar-glass.* A similar feature has been observed in a devitrified obsidian from Mount Alford, Queensland, (Wearne and Woolnough, 1911, p.154) but I am unable to find record of the phenomenon elsewhere.

Combined with the low ferro-magnesian content of the rocks under consideration, it indicates that *they are trachytic in composition, though andesitic in habit.* Trachytes are notably absent from the collection studied, though present in the similar assemblages of Pokolbin (Browne and Walkom, 1911), and Tangorin (Walkom, 1913).

According to the criteria established by Iddings, the quartz of all the acid rocks crystallised rapidly

The accessories are interesting; the iron-ore is probably all titaniferous (Walkom, 1913; Jaquet, 1901). Zircon is remarkably abundant (cf. Benson, 1913, Pt. iii.), while apatite is exceedingly rare, except in (390).

The felspars are all comparatively fresh, and singularly free from the ordinary types of alteration. On the whole, they are more acid than those in the Pokolbin rocks.

The pyroxene-amphibole-mica andesites of Martin's Creek, Paterson, and Eelah, are so exactly alike, except in their degrees of weathering and the consequences thereof, that I have no hesitation in stating that they are derived from the same magma-fraction. The similarity of the resorbtion-effects in both rocks makes it highly probable that they were erupted at the same time.

In the rocks from Eelah, the extent of intratelluric crystallisation, represented by the proportion of phenocrysts to groundmass, was moderately great in the basic members, greater in the intermediate, and slight in the acid. In the basic rocks, centres of crystallisation were few, but the crystals large; in the intermediates, centres were numerous, but the crystals small.

In conclusion, I wish to express my thanks to Professors David and Woolnough for advice and assistance in my work. I would also urge that the mapping already carried out in the Clarencetown district (Jaquet, 1901) be extended to the Hudson's Peak-Eelah district, as much depends on the relation between these two areas. The North Coast Railway should also be traversed while the cuttings are yet fresh. Excellent sections are exposed, especially around Paterson, and between Stroud Road and Dingadee.

LITERATURE.

1913. Benson, W. N.—"The Geology and Petrology of the Great Serpentine-Belt of New South Wales. Part i." Proc. Linn. Soc. N. S. Wales, xxxviii., pp.490-517; Part iii. Petrology. *Ibid.*, xxxviii., pp.662-724.

1911. Browne, W. R., & A. B. Walkom.—"The Geology of the eruptive and associated rocks of Pokolbin, N.S.W." Journ. Proc. Roy. Soc. N. S. Wales, xlv., pp.379-408.

1907. David, T. W. E.—"The Geology of the Hunter River Coal-Measures, New South Wales. Part i." Mem. Geol. Surv. N. S. Wales, Geol. No.4.

1908. Harker, A.—Petrology for Students, 4th Ed.

1909. ————The Natural History of Igneous Rocks.

1911. Iddings, J. P.—Rock-Minerals, 2nd Ed.

1901. Jaquet, J. B.—"The Iron-Ore Deposits of New South Wales." Mem. Geol. Surv. N. S. Wales, Geol. No.2, pp.62-84, Map (gives further references to the igneous rocks).

1901. Kynaston, H.—"On some Tuffs associated with the andesitic lavas of Lorne." Trans. Edin. Geol. Soc., viii., pp.87-90.*

1883. Lossen, K.—"Ueber Porphyroide unter besonderer Berücksichtigung der sogenannten Flaserporphyre in Westfalen und Nassau." Sitzungsber d. Ges. naturf. Freunde zu Berlin, No.9, pp.154-178.†

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* *Fide* Harker. † *Fide* Rosenbusch.

1908. Rosenbusch, H.—Microskopische Physiographie der Mineralien und Gesteine, ii., 2.

1910. ———— ——Elemente der Gesteinslehre.

1905. ———— ——Microscopical Physiography of the Rock-making Minerals. (Trans. by J. P. Iddings).

1913. Walkom, A. B.—"The Geology of the Permo-Carboniferous System in the Glendonbrook District, near Singleton, N.S.W." Proc. Linn. Soc. N. S. Wales, xxxviii., pp.146-159.

1911. Wearne, R. A., & W. G. Woolnough.—"Notes on the Geology of West Moreton, Queensland." Journ. Proc. Roy. Soc. N. S. Wales, xlv., pp.137-159.

(Very little geological literature is obtainable in Perth as yet.)

EXPLANATION OF PLATE XL.

Fig.1.—Pyroxene-andesite; Eelah, (103); crossed nicols, showing coarsely devitrified plagioclase-groundmass; (×24).

Fig.2.—Same rock; ordinary light; (×24).

Fig.3.—Pyroxene-amphibole-mica andesite; Martin's Creek, Paterson, (108); crossed nicols; showing finely devitrified plagioclase-groundmass; (×24).

Fig.4.—Hypersthene-andesite; Eelah, (113); ordinary light; (×24).

Fig.5.—Plagioclase (oligoclase-andesine) with kernel replaced by chlorite in (105); ordinary light; (×28).

Fig.6.—Porphyroid tuff; Eelah, (117); ordinary light; (×24).